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Agriculture

Forest
Service

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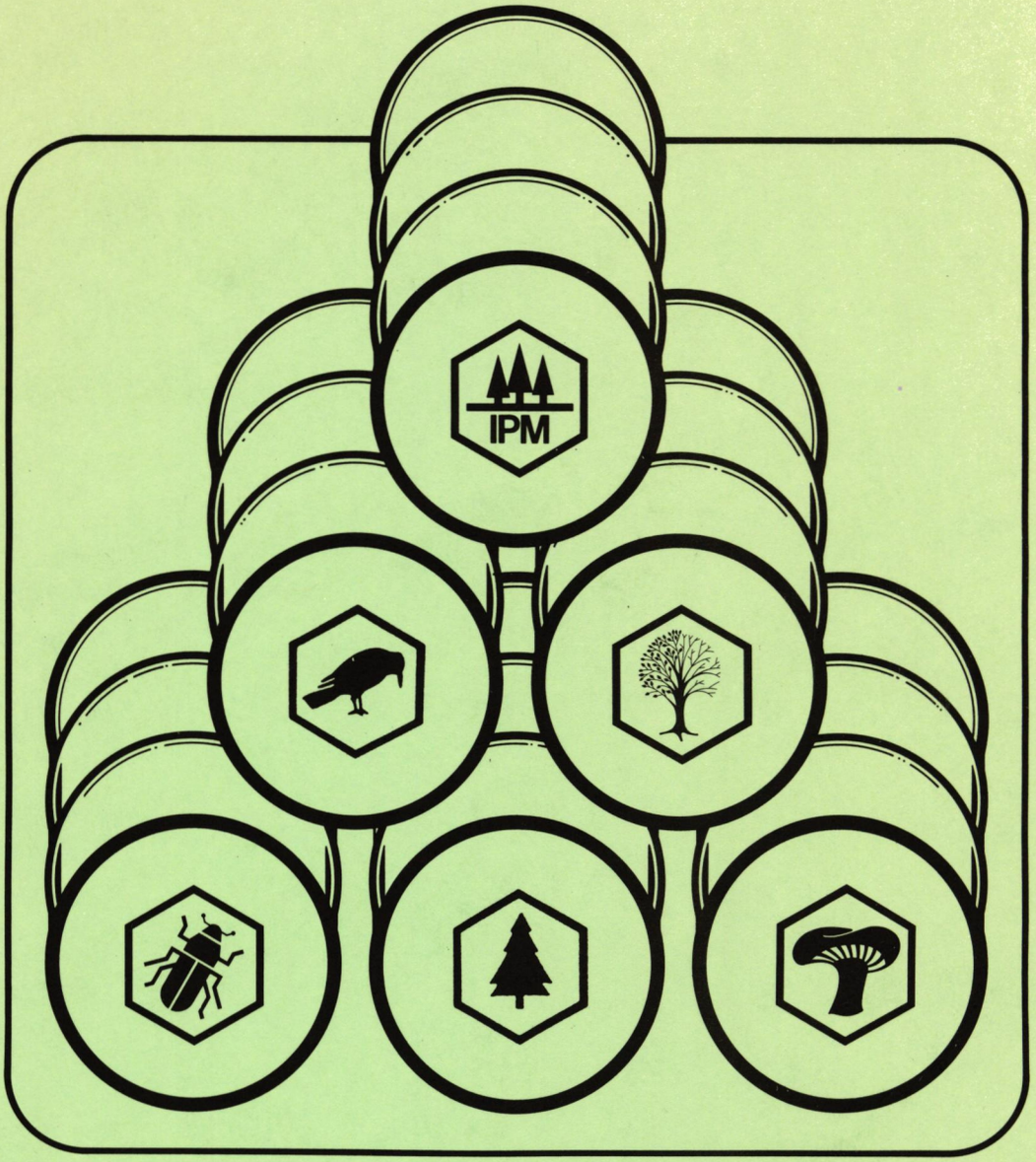
Controlling Pests: When, Where, and How the USDA Forest Service Uses Pesticides



Message from the Chief

Since its inception in 1905, the USDA Forest Service has governed its activities for the greatest good to the greatest number. In that year Secretary of Agriculture Wilson wrote to the Forest Service Chief: "In the administration of the forest reserves, it must be clearly borne in mind that all land is to be devoted to its most productive use for the permanent good of the whole people. . . ."

This is the Forest Service policy long known as multiple use and that was written into law as the Multiple Use-Sustained Yield Act of 1960. Behind it lies the idea that forests and rangelands are more than just trees and grass; they are wildlife refuges, air and water purifiers, recreational areas, pastures for livestock, scientific laboratories, historical and archeological repositories, wood producers, and havens of natural beauty.

Best of all, these benefits are not transient. They are ours forever, constantly renewable resources for all people when they are properly managed.

Over the years, the goals of the Forest Service have not wavered, although the means for accomplishing them have changed with changing times. Technologies have improved, scientific knowledge has increased, economic policies have fluctuated, and the desires of people concerning how they want their public lands managed have shifted.

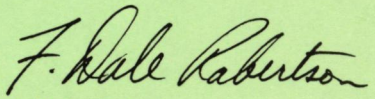
No better example of these changes can be found than in the area of forest pest management. During the pioneer days of our country there was little concern about the effects of insect and plant pests in our natural forests. There seemed to be an abundance of trees for every use for everyone. But as populations grew and moved west, their demand for wood, paper, and other forest and rangeland products increased, particularly over the last half century. Today we use over 200 million tons of lumber each year. On the average each American uses almost 600 pounds of paper every day for some 100,000 different purposes. That means that each of us, each one of our 240 million people, uses the equivalent of a tree 100 feet tall each year. Each day each of us breathes the oxygen produced by at least one tree. And although we do not often relate food production with National Forest System land, much of the meat we eat comes from cattle and sheep grazed on National Forests and Grasslands.

It is apparent that we must ensure the continuation of healthy and vigorous forests and grasslands. More than that, we must ensure better, more productive public lands. The Department of Agriculture and the Forest Service are committed to these objectives and to their fulfillment through wise management.

Among a variety of tools developed to assist foresters and range conservationists is the practice of integrated pest management, which includes the use of pesticides when warranted. Pesticides, including insecticides, herbicides, fungicides, fumigants, rodenticides, predacides, and repellants, are invaluable tools, their uses ranging from the protection of nursery seedbeds to the preservation of research plots for developing super trees. Not least among their uses is the control of animal and plant species that often impede land management objectives.

Unfortunately, in recent years, even the judicious use of pesticides as a tool in forest and rangeland management has created intense controversy. Uncertainty about hazards from pesticide use has been exploited. Federal agencies have been criticized for using pesticides indiscriminately, without scientific support, and with little regard for actual need, impacts on human health, or environmental consequences. These are serious criticisms.

This packet has been prepared, therefore, to provide an overview of **when, where,** and **how** one Federal agency, the USDA Forest Service, uses pesticides as one tool in the management of the Nation's forest and range resources. Admittedly, pesticide use plays a relatively small role in integrated pest management today, but that role is pivotal. Without pesticides, many products of our forests and rangelands would never see the light of day. Pesticides remain critical in supplying needs for natural resources now, and are crucial in meeting demands that will grow even more in the future.



F. Dale Robertson
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The Role of Pesticides in Integrated Pest Management

The phrase "pest management" has one unfortunate implication: it seems to indicate that all pests can be lumped together and have much in common. And that leads to the conclusion that some panacea may exist that will eradicate all of them, if one can but find it.

But the catchall word "pests" encompasses thousands of different life forms, their only commonality being that they compete with human society for the same natural resources. Pests are not defined in terms of biological characteristics, but in terms of how their behavior affects society's goals. Every insect, animal, and plant in a forest has carved its own niche in the ecosystem through generations of adaptation. Each contributes to the cycle of birth, growth, reproduction, death, and decay that keeps nature in balance. When a plant suppresses a tree needed by society for lumber, however, it becomes a weed. When a bark beetle kills a tree needed by society to make paper it becomes a pest.

It is hardly surprising that there can never be a single method for controlling a group of living organisms that includes pocket gophers, poison ivy, trash fish, mistletoe, rabbits, fungi, grasshoppers, blackjack oak, the southern pine beetle, and littleleaf disease.

What is required is a battery of techniques, an arsenal of methods, some one or more of which should be able to hold in check any threat to the resources society has laid claim to. That is one of the benefits of integrated pest management (IPM). IPM is, of course, more than a catalog of methods; it is a decisionmaking process requiring the consideration of all techniques. The final selection of one or more is based on what will best accomplish management objectives with the least environmental impact.

There is another concept that is sometimes overlooked except by specialists in forest pest management. The approach and the techniques of pest management designed to **prevent** pest damage are quite different from those aimed at **suppressing** pests. This, too, is covered in IPM.

Another complicating factor in pest management is site specificity. One method for dealing with an insect pest in a managed stand of trees on level ground with access roads may be totally impractical in a stand that has naturally seeded in, on a steep slope where roads are not only absent but impossible to build.

That brings up the costs of treatment. Is the value of the trees greater than the cost of treating them? It is seldom easy to determine the economic threshold in forest management, for the value of forest stands usually has more than one basis. Value as standing timber must be weighed against value as wildlife habitat; value as an esthetic resource; value as a recreational area for hunting, fishing, nature trails, camping, or birding; value as erosion control and flood prevention; and value as a source of clean air and water. Also to consider is the value of adjacent land. An insect infestation on relatively low value land may, if left unchecked, spread to nearby land of great worth. In the West, a similar situation exists with plant pests; noxious weeds on rangeland (where they injure both wild and domestic animals) can spread to farm lands, destroying their ability to produce food and feed. (This topic is discussed further under the heading "Evaluating Pest Problems.")

These, then, are some of the considerations that led to an integrated approach to pest management, to IPM. This decisionmaking process is an ecologically based system that relies on evaluations of mechanical, manual, silvicultural, biological, and chemical means to reduce pest losses. Whenever possible, pest problems are avoided through proper forest and range management.

In IPM, the ounce of prevention is sought first. This strategy usually employs cultural, i.e., silvicultural, measures of demonstrated effectivenes in making forests less suitable to pests. Planting stock that is genetically resistant to pest species is an example. Other methods are matching site and planting stock, selecting and planting pest-free seeds and seedlings, altering stand density and species composition, and promptly reforesting harvested or damaged areas. Using these tactics requires months, sometimes years, of planning based on knowledgeable foresight.

Biological control is another significant part of integrated forest pest management. This strategy pits natural organisms against one another to serve the goals of resource managers. Parasites and predators are often used to restrict pest populations to levels that will not cause economic injury. An example is the spurge hawk moth, an effective antagonist against the noxious weed leafy spurge on western rangeland. Biological insecticides are playing an increasing role in Forest Service IPM programs too. The bacterium *Bacillus thuringiensis* has proved successful against spruce budworms, tussock moths, cankerworms, tent caterpillars, and other forest defoliators.

A Forest Service contribution to biological control is the development and production of viruses for forest insect control. The Douglas-fir tussock moth (DFTM) virus has been produced at a Forest Service operated facility in Corvallis, OR. Nearly 200,000 acre-equivalents of the DFTM virus, registered with the U.S.

Environmental Protection Agency as TM-BioControl 1, are now on hand and available for use in IPM programs in Canada and the United States.

Other viruses initially researched by Forest Service scientists are being marketed by commercial manufacturers for use in control programs against sawflies and other defoliators. Pheromones, chemical communicators of insects, are also being studied by the Forest Service for their potential in managing populations of bark beetles, defoliators, and cone and seed insects.

Biological control agents have the disadvantage of working slowly. Before they can take full effect, tree losses often occur. There are occasions when insect epidemics arise rapidly even in well-managed stands. When pest problems are unavoidable, they are handled in the most effective and environmentally safe way that is consistent with management objectives. There are times when this means the application of conventional chemical pesticides.

When pesticides are used by the Forest Service, only those registered by the U.S. Environmental Protection Agency are applied. They are used strictly according to label instructions and by trained applicators. In some situations, they are the only means of stopping unacceptable pest damage, and for that reason are likely to remain an important part of integrated pest management in forestry. It is noteworthy that use of chemical pesticides in forestry is minimal. The Forest Service applies less than 1 percent of the pesticides used in the United States each year.

Evaluating Pest Problems

The mere presence of insects, vertebrate animals, diseases, or weeds in a forest stand on National Forest System land does not necessarily lead to pest control efforts. These life forms are as much a part of a forest as trees are. The changes they bring about in the ecosystem are functional. Destructive bark beetles, for instance, are food for birds and predatory insects. Their destruction of trees opens dense areas, allowing new growth and improving wildlife habitat. Their activity also contributes to variations in stand composition and forest succession. Only when organisms cause damage that adversely affects landowners' objectives are they rightfully called pests.

The size of insect populations and extent of disease infections are cyclic in nature. Every year hundreds of insect and vertebrate populations as well as plant diseases rise and then subside before causing unacceptable damage. Competing vegetation may not result in enough loss of tree growth to merit treatment. Before deciding whether control action should be taken, each pest situation must be evaluated individually.

Evaluation is an essential first step in determining the need for and the extent of pest control operations on public forest lands. An evaluation has two components — a biological evaluation and an economic analysis. The biological evaluation identifies the pest and determines the likely course of events if the outbreak is unchecked,the probable damage or loss to be expected, the most effective method of control action, and the probable reduction of damage or loss as a result of management action.

When the biological evaluation indicates the pest will persist, intensify, and seriously damage the forest, an economic analysis follows. This assesses the impact of the pest on the forest and its wildlife, recreation, timber, water, and esthetic values. The economic analysis appraises the value of the resource at risk, the cost of the proposed control action, and the benefit to be derived from the control. Only when anticipated benefits meet or exceed costs is a control project considered further.

The results of both biological and economic analyses are weighed by forest pest management personnel and ultimately incorporated into the structured process required by the National Environmental Policy Act of 1969. A decision to treat a forest stand, especially with pesticides, is not reached unilaterally. Members of the public, both individuals and groups, likely to be affected by the proposed action are consulted and encouraged to participate in the decisionmaking process. In addition, proposals to use pesticides are reviewed by interdisciplinary teams to ensure that the application of a pesticide is appropriate, that the proposed pesticide is registered with the U.S. Environmental Protection Agency, and that the correct formulation has been selected to ensure the least environmental impact.

When, after all these considerations, the decision is made to proceed with pesticide applications, every phase of the operation is monitored throughout the treatment to ensure the safety of workers and the public and preserve the integrity of the environment.

The Role of Pesticides in Forest Health

A forest is a complex living organism not unlike the human body. It is subject to stress, disease, and invasion. It can be treated by specialists to restore health, but it's best to develop stands that are vigorous and can withstand assault.

Like a human being, a forest can become enfeebled by persistent attack, lie unproductive through want of attention, or die from a pest epidemic. And like a human patient, an ailing forest can sometimes be saved by drastic action on the part of a specialist.

To continue the analogy, a large part of integrated pest management (IPM) is like preventive medicine. By using silvicultural measures of demonstrated effectiveness, IPM seeks to keep forests in a condition unfavorable to pests. This is done by planting genetically resistant stock, selecting and planting pest-free seeds and seedlings, matching site and planting stock, altering stand density and species composition, promptly reforesting harvested or damaged areas, and thinning to promote more vigorous trees.

When, in spite of preventive measures, a stand or forest becomes endangered, techniques are used that are least likely to harm the ecosystem. Doctors vaccinate human patients, using biology to fight one microbe with another. Forest pest management specialists use natural parasites and predators of pests to keep destructive insects below population levels that could destroy trees.

Other biological control methods against forest pests include the use of bacteria, viruses, and pheromones to mitigate or reduce pest populations. With all these alternatives available, however, pests still occasionally reach epidemic porportions. For a variety of reasons, sometimes only drastic solutions will alleviate the problem. In similar situations doctors resort to surgery or to strong medicines. Pest management specialists resort to pesticides.

Gypsy moths, tent caterpillars, and spruce budworms are defoliators; their larvae eat tree leaves and needles. An epidemic of such pests can adversely affect a forest. Started early enough, treatment with the biological insecticide *Bacillus thuringiensis* can be effective, but it acts slowly. An overwhelming population of caterpillars can sometimes be stopped in time only with a chemical pesticide. When the trees in jeopardy are highly valuable, this may be the only medicine that can be prescribed to save them.

Sometimes the magnitude of the pest problem suggests a resort to chemicals. In the West, hundreds of thousands of acres of once productive land are being invaded by leafy spurge, knapweed, and other noxious and poisonous weeds. Their growth chokes out beneficial plants, sickens and kills livestock and wildlife, renders farmland unproductive or less so, and endangers the economic stability of entire communities. The areas involved are so vast that all types of tools are needed, including mechanical, manual, and biological treatment, as well as pesticides. During a 5-year period an average of 14,000 acres was treated with 23,000 pounds of pesticides for this purpose, as shown in the table below.

Pesticide use for noxious weed control on National Forest System lands

	Acres	*Pounds*
1982	17,589	29,239
1983	7,567	6,191
1984	12,390	20,683
1985	19,249	39,025
1986	15,569	20,773

Some trees require direct sunlight to survive, particularly when they are seedlings just getting a start. If they are overtopped by other vegetation, they may wither and die. Many such trees are economically important, yet it would not be cost effective to manually or mechanically remove competing vegetation. For one thing, it would have to be done over and over again as the weeds regenerate. Chemical treatments can often hold weeds in check long enough for the valuable trees to get a foothold. Even before seedlings are set out, planting sites are prepared by removing vegetation that would compete with young trees for sunlight, water, and soil nutrients. This site preparation also ensures that the land is in condition for proper spacing of seedlings. An average of about 56,000 acres were treated for site preparation from 1982-86.

Pesticide use for site preparation on National Forest System lands

	Acres	*Pounds*
1982	93,191	151,553
1983	53,934	135,258
1984	42,987	93,477
1985	47,491	94,507
1986	42,769	91,414

Tree seeds are particularly vulnerable to attack by fungi and rodents. Without fumigants to cleanse the soil and rodenticides to curb the mice and pocket gophers, it would be difficult indeed to produce enough viable seeds and seedlings to ensure the proper regeneration of our forests. During a 5-year period (1982–86) rodents on National Forest System lands required control on an average of 70,000 acres.

Pesticide use for rodent control on National Forest System lands

	Acres	*Pounds*
1982	61,817	1,443
1983	57,697	3,009
1984	89,757	4,726
1985	72,199	2,869
1986	71,303	1,808

These are a few uses of pesticides within the framework of IPM. They are strong medicines, but when they are needed, they are vital. No doctor wants to advise surgery or prescribe a medication that may have uncomfortable side effects, but often such remedies are required to save lives. No forest pest manager particularly wants to use pesticides, but when they will save valuable trees, the specialist knows that pesticides are there, an invaluable tool among the alternatives of integrated pest management.

Use of Pesticides in Forestry

Any attempt to judge the extent of pesticide use on National Forest System lands by the amount of controversy expressed in news stories, magazine articles, and court cases would give a decidedly exaggerated picture.

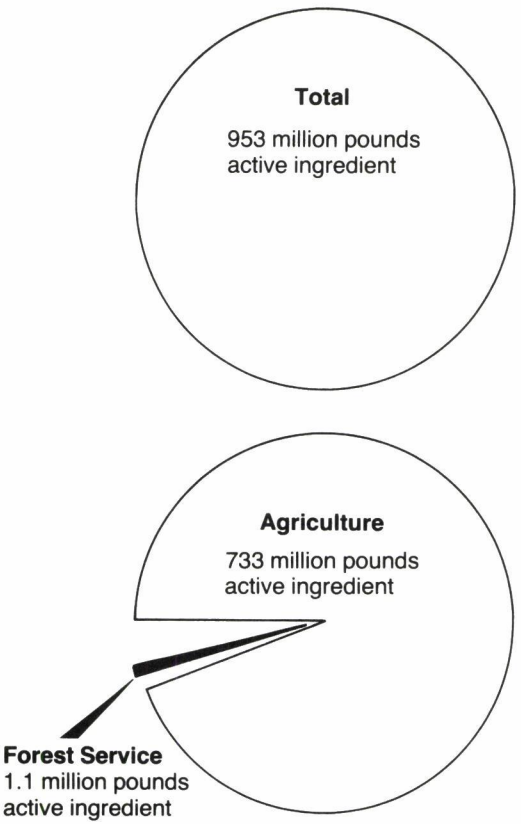
The relative amount of pesticides used each year by the Forest Service compared with other users in the United States is very small. The Forest Service administers 191 million acres of forest and rangeland. Based on a 5-year average (1982–86), the Forest Service treats about 700,000 acres annually with pesticides. That works out to less than 0.3 percent of NFS land treated each year. That's not 3 percent; that's three-tenths of 1 percent.

Another way the quantity of pesticides used can be measured is in terms of active ingredient. Most commercial pesticides are composed of a chemical that directly controls the pest — the active ingredient — plus materials that serve as carriers, wetting agents, adhesives, or other such additives.

The total volume of active ingredient used in the United States in 1983 was about 953 million pounds. About 75 percent of this was used in agriculture. More than 24 percent was used by homeowners and others. The Forest Service used 1.1 million pounds, less than 1 percent of all pesticides used in the United States.

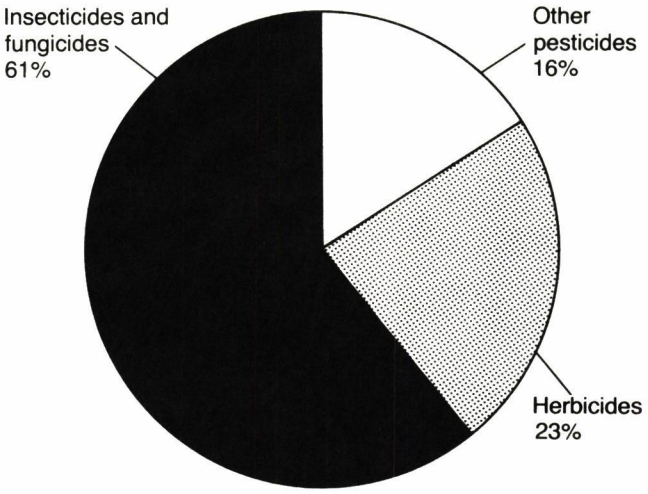
The 5-year average from 1982–86 was even less, 817,000 pounds. In terms of active ingredient, of the pesticides used by the Forest Service (1982–86), insecticides and

Volume of pesticide active ingredient used in the United States, 1983.



fungicides for insect and disease control accounted for about 54 percent; herbicides for vegetation control, about 45 percent; other pesticides, about 1 percent. In terms of acreage covered, 61 percent of the average of 787,000 acres treated were treated with insecticides and fungicides; 23 percent, herbicides; and 16 percent, other pesticides. The chart below shows the percentage of acreage treated from 1982–86.

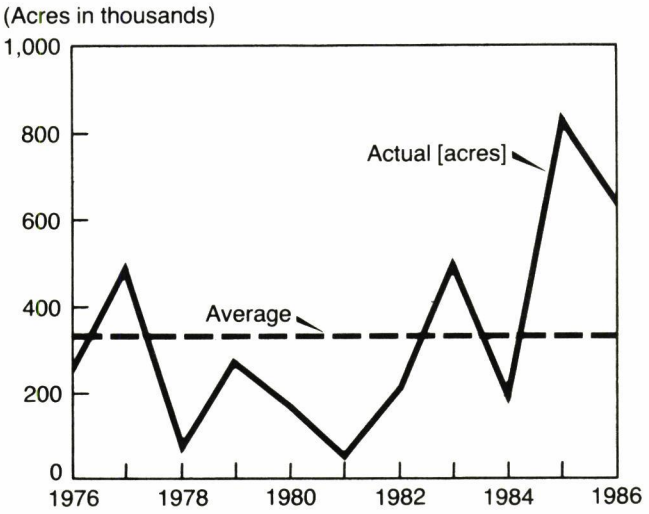
Pesticide use on National Forest System lands, 5-year average (1982–86) of acres treated.



Some of the conventional insecticides most often used for controlling major forest insects are acephate, carbaryl, malathion, and trichlorfon for defoliators; lindane, chlorpyrifos, and carbaryl for bark beetles; and carbofuran, acephate, and azinphos-methyl for seed and cone insects. The chart below shows insecticide use on National Forest System lands for the 11-year period 1976–86. On average about 300,000 acres are treated with insecticides each year.

Biological insecticides, including the bacterium *Bacillus thuringiensis* and small amounts of virus

Insecticide use on National Forest System lands, 1976–86.



specific to the Douglas-fir tussock moth and the gypsy moth, have also been used to reduce populations of these pests and to protect foliage. Behavioral chemicals such as attractants and repellants are also being used in integrated forest insect management programs.

A new generation of pesticides, the growth regulators, is now being used with increasing frequency. Diflubenzuron is an example. This synthetic insecticide contains an ingredient that inhibits moulting, preventing maturation and reducing populations. These materials may be considered intermediate between conventional chemical pesticides and the biologicals; although they are manufactured, their effects simulate biological processes within the insect. The current trend in forest pest management is to use these new generation insecticides combined with biologicals. Their increased use has led to a decline in the use of conventional chemical insecticides.

Insect and Disease Management

Successful managers of stores could be called customer managers. They stock their stores with products customers want to buy and arrange them attractively to promote sales. As a result store managers modify the behavior of customers; customers come to their stores more often than to those of their competitors.

Forest managers approach their work in like manner—in reverse. They stock their forests and perform certain actions to make their "stores" unattractive to pests and disease agents. They deal with their resources in such a way that they modify the behavior of unwanted "customers."

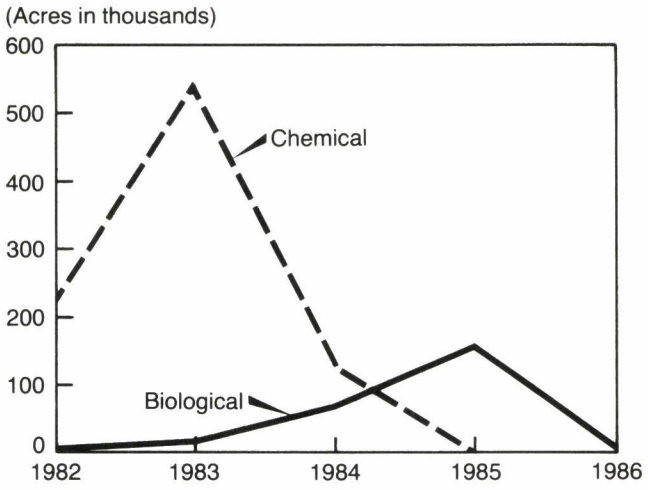
Integrated pest management (IPM) is the system used by resource managers in the Forest Service to achieve this goal. It aims at economical pest control in an environmentally and socially acceptable manner. The basic objectives of IPM in forestry are management of forest resources so as to reduce or eliminate pest problems; reduce reliance on potentially hazardous chemicals; develop additional environmentally sound pest management tactics; pilot test and demonstrate the effectiveness of new systems; provide training; and encourage the use of workable, practical systems.

Silvicultural practices that mitigate insect damage include removing trees that have a high risk of attack, thinning stands to improve tree vigor, prompt salvaging of infested trees, disposing of logging residues, and expeditious harvesting of damaged or windthrown trees. Risk-rating systems have been developed that allow the identification and removal of trees susceptible to attack from bark beetles, spruce budworms, and gypsy moths.

The regeneration of forests is one of the most important aspects of forest management. It is the business of providing for the future, and it starts in seed orchards and nurseries. Here, too, cultural practices discourage pests. By managing irrigation, improving soil fertility, regulating seedling density, taking advantage of natural exposure to sunlight, and removing nearby alternate hosts, pest problems are averted. The use of weather forecasting can minimize losses and reduce pesticide use and costs by informing nurseries when conditions are favorable for certain pests. Another beneficial practice is the proper timing between lifting, fallowing, and planting to reduce pest losses in nursery beds.

The discovery of new, effective biological control agents has contributed to a decline in the use of chemical control of pests. Behavioral chemicals such as confusants, attractants, repellants, and inhibitors also show promise for integrating with other practices and subsequently reducing the use of conventional chemicals, as shown in the following chart.

Chemical versus biological insecticide use for western spruce budworm control on National Forest System lands, 1982-86.



Several microbial insecticides are in use to control forest insects. The most effective are *Bacillus thuringiensis* for control of lepidopterous pests, and two nucleopolyhedrosis viruses that have been registered by the USDA Forest Service for use against the Douglas-fir tussock moth and the gypsy moth. Another current biological control is the deliberate release of a pest's natural enemies—parasites and predators—to reduce forest pest populations.

The control of forest pathogens—diseases—is governed by management objectives. Diseases, like other pests, play a natural role in forest ecosystems. Generally, therefore, only intensively managed forest areas are subject to control of pathogens. Although most control strategies are cultural, the use of pesticides is important, especially on the several hundred thousand acres of specialty forests such as nurseries, seed orchards, and windbreaks or shelterbelts. In nurseries, the fumigant methyl bromide and the fungicides dichloropropene and ferbam are important in controlling diseases. Borax is an effective fungicide in the field, used to control root rot fungi in southern pines. Other fungicides used in forestry are benomyl, captan, and chlorothalonil.

The biological control of disease organisms is receiving increasing interest. For example, one approach involves

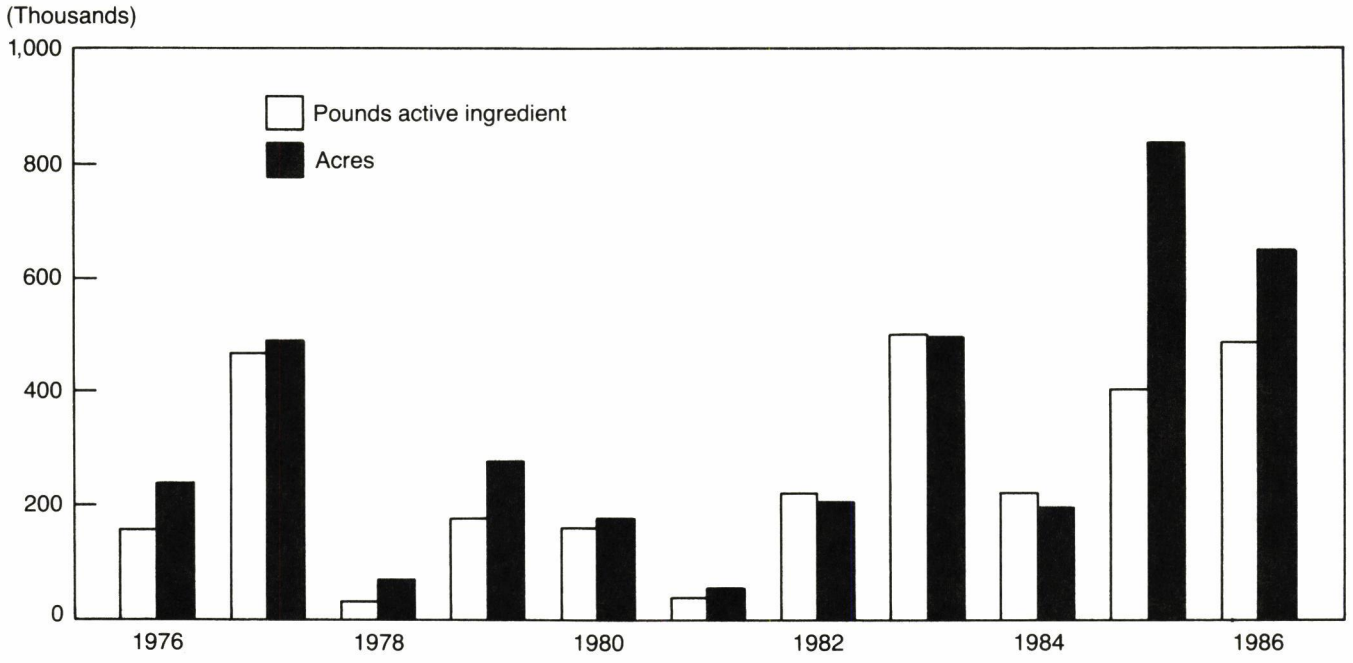
the development and use of a fungal antagonist *(Peniophora gigantea)* that competes for substrate with a disease fungus *(Heterobasidion annosum)*.

In the past, forests and forest products have sometimes received frequent pesticide applications. But as the effectiveness and economic advantages of integrated pest management become more fully demonstrated there will be less reliance on conventional pesticides. Because IPM offers the promise of dependable pest control with minimal adverse environmental effects, its use will become more widespread.

It is also recognized that pesticides will continue to remain integral to IPM programs for those situations where they are the fastest, safest, and most cost-effective means for preserving our forests. A look at the pattern of insecticide use over an 11-year period on National Forest System lands demonstrates this reality, as shown in the chart below.

The average number of acres treated from 1976 through 1986 was about 300,000. In 1975, 1978, and 1981, fewer than 100,000 acres required treatment because fewer outbreaks of forest insects occurred. In 1983, however, populations of the western spruce budworm increased dramatically, and in 1985 and 1986 grasshopper epidemics alone accounted for over 600,000 acres of treatment each year. At present there are no substitutes for chemical pesticides when almost unbelievable numbers of insects threaten our natural resources.

Insecticide use on National Forest System lands, 1976-86.



Controlling Pest Vegetation

A Saturday morning spent on one's knees troweling weeds from the flowerbeds is enough to convince most homeowners that there has to be a better way. Forest managers agree, particularly since their weeds are sometimes 30 feet tall with stems 10 inches thick. Weed trees are not the only reasons foresters often forsake manual treatment and turn to herbicides in pest vegetation management.

The purpose of controlling pest vegetation is to arrest, reverse, or hasten plant succession to enhance the generation of various products human beings want from the land. Controlling pest vegetation involves the manipulation of the kinds, amounts, quality, and condition of vegetation resources. This activity can be broken down into eight major categories: noxious weed control, range improvement and maintenance, site preparation for timber production, conifer release, thinning, rights-of-way maintenance, fire protection, and general weed control.

Integrated vegetation management programs can be accomplished in a number of ways: using mechanical equipment, prescribed fire, manual clearing, insects and diseases, grazing, chemical herbicides, or a combination of methods. Some problems can be prevented or minimized by cultural practices that discourage weeds or give the advantage to desirable plant life.

Because of the great variation in field conditions, treatment prescriptions must always be site specific. Some of those variations are: 1) ecological requirements of the desired species; 2) objectives of the treatment; 3) species, size, and stocking of desirable trees; 4) composition and structure of ground cover; 5) physical site factors such as terrain, exposure, soil type, erosion hazard, size of treatment area, and access; 6) availability of manpower and equipment; 7) external constraints such as government rules and regulations; 8) proximity to ecologically sensitive areas; and 9) goals of owners of adjacent land.

Cost-effectiveness is a critical factor, particularly in forestry, because investments must be carried for long periods of time. Investments such as vegetation management and reforestation are made early in the lifetime of a stand of trees and must be continued until those trees are finally harvested. Consequently, these investments are compounded longer and have a higher degree of risk than other kinds of investments.

Among the alternatives available in integrated vegetation pest management, herbicides are often the choice of last resort. This is not because they are ineffective or costly—quite the contrary. But there is a perception among many people, including some professionals, that they are unsafe. Although herbicides are markedly less toxic than insecticides, they do have to be handled with care. That is why the Forest Service uses only herbicides registered by the U.S. Environmental Protection Agency (EPA), strictly follows label regulations, and thoroughly trains its applicators in safety precautions as well as proper application technology.

There are times, however, when herbicides are the best choice for getting the job done. The following paragraphs discuss some situations when other alternatives would prove counterproductive.

Mechanical techniques require heavy machinery such as bulldozers. They cannot be used on steep terrain or on fragile, erosive, easily compacted soil. Mechanical methods are unsuitable also for tree release where small trees are hidden by brush or for precommercial thinning and timber stand improvement where individual tree selection is needed. Mechanical methods are all relatively costly.

Prescribed burning, inherently controversial, lacks selectivity. The amount of fuel on the forest floor must not be so great that loss of control is possible. Too much fuel can burn so hot that standing trees will be damaged. The range of weather conditions for safe use is very narrow. The possibility of violating air quality standards is high, particularly as those standards become more restrictive.

Competing vegetation can be removed by chainsaws, axes, or other manual equipment. All are highly dangerous to the user. Treatment costs are among the highest. Manpower is often limited or lacking. Vegetation removed manually resprouts rapidly, necessitating further treatment and additional costs.

Grazing as a vegetation management tool is quite uncertain. Although goats will graze brushlands and help maintain fuelbreaks, and cattle and sheep eat grasses and herbaceous species, the animals are not easily controlled. Soil compaction, the long period of time to obtain control of competing vegetation, and damage to desirable species are major deterrents to the use of grazing. Other limitations are created by livestock predators, lack of experienced herders, low return on investment in livestock, the need for fencing, and areas requiring treatment that may not be economically suitable browsing or grazing units.

Present efforts to locate, test, and use insects and diseases to control undesirable vegetation have focused on economically important introduced weeds in agricultural crops and on noxious weeds. A problem with this method in forestry arises because effective control requires repeated defoliation and killing of resprouting stems in successive years. Introduced biological organisms that compete with or consume introduced weeds pose other problems. They seldom become established in the new environment and the cost of repeated introduction is prohibitive. Life cycles and mass-rearing techniques for organisms of potential usefulness are largely unknown, and the proper timing, intensity, and distribution of outbreaks are unpredictable. Confining the effects of introduced species to treatment areas is also difficult to achieve.

Cultural methods are not as widely used today as their usefulness warrants. For one reason, forest land managers often work with previously unmanaged stands. Another reason is that there is often a lack of basic ecological information about the major commercial tree species and their competitors. Before cultural control methods can be fully implemented, information is needed on reproductive capabilities, relative growth rates, and competitive ability of individual species and species mixtures.

In spite of the shortcomings of these vegetation control methods, weeds must be controlled if our forests and grasslands are to remain productive. An estimated 39 percent of commercial forest land in the United States is dominated by undesirable vegetation. The situations in which nonchemical methods of vegetation management are unproductive often occur and they often occur in combination, leaving treatment with herbicides as the only viable alternative. Properly used, it is efficient, cost effective, and a safe tool in integrated vegetation pest management, and will continue to play its part in keeping our forests and grasslands productive and safe.

Herbicide use for various activities on National Forest System lands, 1982–86

Activity	1982		1983		1984		1985		1986		5-year average	
	Acres	*Pounds*	*Acres*	*Pounds*	*Acres*	*Pounds*	*Acres*	*Pounds*	*Acres*	*Pounds*	*Acres*	*Pounds*
Noxious weed control	17,589	29,239	7,567	6,191	12,390	20,683	19,249	39,025	15,569	20,773	14,472	23,182
Range management	28,751	43,351	30,963	44,051	8,959	11,709	4,911	7,060	4,774	5,578	15,671	22,349
Conifer & hardwood release	79,704	137,043	119,669	262,597	60,955	160,029	61,102	103,254	61,024	86,087	76,490	149,802
Site preparation	93,191	151,553	53,934	135,258	42,987	93,477	47,491	94,507	42,769	91,414	56,074	113,241
Thinning	2,407	4,058	4,879	3,816	144	136	914	2,845	3,834	9,013	2,435	3,973
Right-of-way maintenance	15,736	41,967	15,099	47,157	5,061	19,917	6,111	15,045	4,352	16,685	9,271	28,154
General weed control	2,465	6,552	1,124	4,810	1,377	4,586	2,387	2,524	1,780	1,956	1,826	4,085
Aquatic weed control	67	1,190	70	420	157	446	280	552	353	1,644	185	850
Firebreak maintenance	601	1,203	2,573	6,406	470	8,715	1	7	94	36	747	3,273
Wildlife habitat management	6,358	8,342	7,677	12,033	7,841	20,082	7,412	10,339	5,605	11,623	6,978	12,483
Nursery management	1,024	3,597	1,518	3,995	1,566	4,622	756	2,084	757	1,735	1,124	3,206
Research	172	483	0	0	21	30	611	777	237	107	208	279

Pesticide Application Techniques

In forestry, pesticides are useful for a number of purposes: herbicides control undesirable and competing vegetation; fungicides and fumigants control nursery diseases; predacides, piscicides, avicides, and repellants control animal damage; and insecticides suppress outbreaks of damaging insects. Most of the pesticides used in forestry were first used in agriculture. Their uses were then tailored to fit the special requirements of the forest environment.

Formulations, dosages, application methods, and potential hazards are thoroughly researched and tested before any pesticide is used. Small-scale field experiments and subsequent larger pilot tests determine the feasibility and applicability of these chemicals for use by pest management specialists.

When a pest problem requires the use of a pesticide, one of the decisions to be made is the method of application, whether ground or aerial. This is a factor in the selection of the pesticide. Most pesticides used by the Forest Service are applied with ground equipment. Herbicides, for instance, can be applied directly to the target site by injection, hack and squirt techniques, basal stem and cut-surface spraying, and other ground application methods. These techniques have not attracted much public attention, possibly because the areas treated are small, localized, and not generally visible outside the forests. Historically, however, 75 percent of the herbicides used on National Forests have been applied with ground equipment.

Aerial application, on the other hand, both by helicopter and fixed-wing aircraft, has received considerable attention and a great deal of criticism. Flying objects are, of course, quite visible; so is the material they spray. Pesticide drift does occur and vaporization allows minute particles to travel outside the swath of the aircraft.

Few subjects have received the scientific attention that drift has. Studies have pinpointed the effects of a multitude of nozzle types using a variety of pesticides under varying conditions of weather, aircraft speeds and altitudes, and system pressures. This knowledge is applied during operational flights to ensure that no harm comes to people, domestic animals and wildlife, or the environment.

To be doubly sure of safe application, buffer zones are established near open water, dwellings, farm crops, and domestic animals. The buffer zones are sufficiently wide to keep drift well away from anyone or anything that might be injured. Further, specific requirements are followed regarding nozzles, system pressure, orientation to the airstream, atmospheric conditions, and observations during application.

Many people seem to believe that most pesticide application is by air. The fact is, when aerial spraying is an operational alternative, even herbicides are applied by air only 25 percent of the time on National Forests. This is true even though there is the advantage that much less pesticide is needed to do the job by air than is required for ground application. And the job gets done much more quickly. Both these circumstances mean less pesticide in the environment. The following table shows the acreage treated by herbicides and the percentage treated aerially on National Forest System lands during 1982–86.

On March 30, 1984, the Chief of the Forest Service instituted a voluntary deferral policy on the aerial application of herbicides. This policy resulted in no aerial application of herbicides in 1985 and 1986. Although the policy remains in effect, in 1987 projects will be evaluated on a case-by-case basis to determine whether aerial application will be allowed. The following chart shows how herbicide use on National Forest

System lands has declined in the last 3 to 4 years. The 11-year average has been about 186,000 acres treated.

Application of herbicides on National Forest System lands, 1982-86

	Total acres treated	Acres treated aerially	Percent of total acres treated aerially
	Number		*Percent*
1982	248,083	56,857	23
1983	245,059	67,584	28
1984	141,928	2,090	1
1985	150,614	0	0
1986	141,148	0	0
Average	185,366	25,306	14

Insecticides, on the other hand, are applied by air to about 98 percent of the acres of National Forest System lands treated each year (see table upper right).

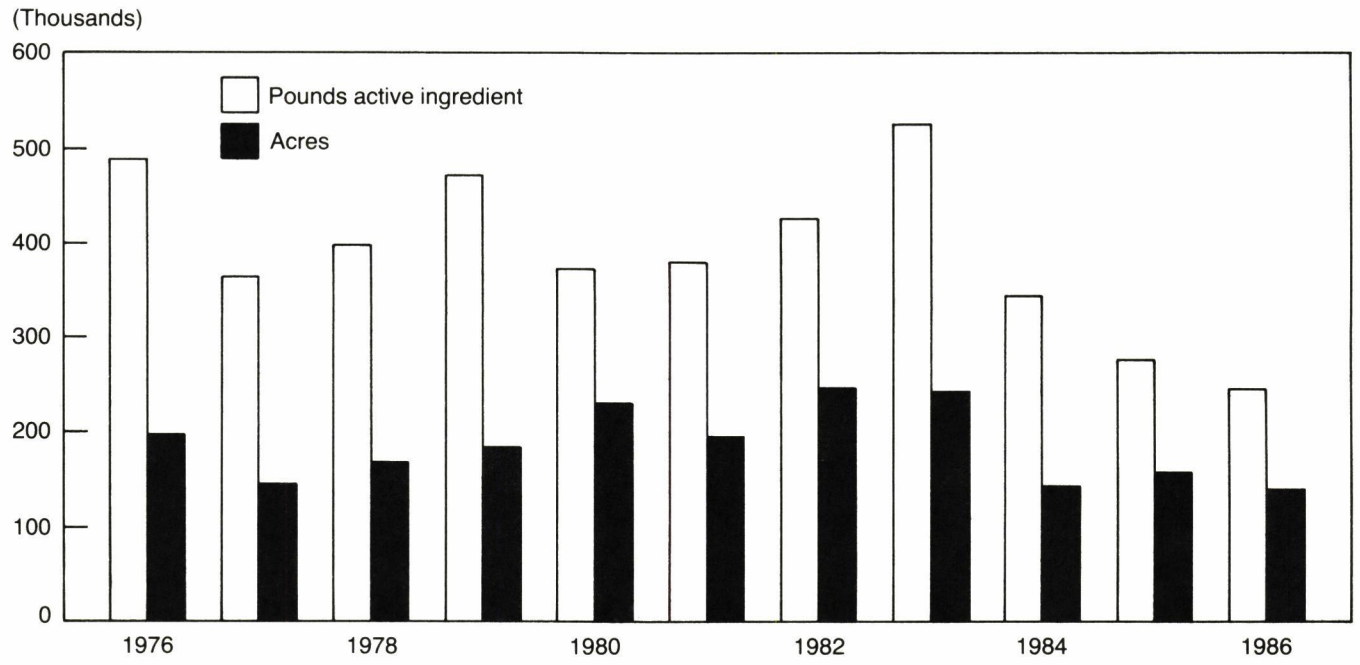
Even though the aerial application of pesticides in forestry is low, the perception of risk remains. It is

Application of insecticides on National Forest System lands, 1982-86

	Total acres treated	Acres treated aerially	Percent of total acres treated aerially
	Number		*Percent*
1982	205,148	203,696	99
1983	493,856	491,451	99
1984	191,291	176,849	92
1985	831,240	799,060	96
1986	643,305	641,339	99
Average	472,968	462,479	98

sometimes expressed in unusual ways. In two situations people have claimed illnesses, spontaneous abortions, and physical abnormalities after being near a spray operation. In one case the airplane was seeding rice and in the other the plane was spraying water to check the nozzles. Only a better knowledge of the process can alleviate the fears about this most efficient and safe application method.

Herbicide use on National Forest System lands, 1976-86.



Animal Damage Management

Animals with backbones are called vertebrates and that classification contains a strange assortment of beasts. People are among them. Some of these creatures can become pests in forests and on grasslands. People are among those, too, as anyone can testify who has seen the results of a wildfire, carelessly or intentionally set by a human being.

Our concern here, however, is vertebrate pests of the four-legged variety. Hardly anyone would question the inclusion of rodents in that category. These voracious eaters consume or besmirch tons of agricultural products each year. The damage mice can do to seedbeds in a tree nursery and the havoc that prairie dogs create on grasslands can be major economic catastrophes.

All vertebrate wildlife considered, its damage to forested land is probably insignificant compared to the esthetic and recreational values it affords—except in the early stages of forest regeneration. Then the clipping and browsing by rabbits, pocket gophers, deer, and elk become serious problems.

Because many of the animals themselves are important natural resources, there is increasing emphasis on integrated management approaches that deter wildlife without harming it. Noxious repellants have been developed, compounds that produce an undesirable taste, odor, feel or that otherwise modify behavior patterns. One of the most common repellants in use today is putrescent whole egg solids that are formulated variously to protect forest seedlings from deer, elk, mice, and rabbits.

Another extremely important alternative is habitat management. This strategy involves removing or not leaving attractive food or habitat near reforested areas. Accumulations of brush, for instance, are agreeable abodes for pocket gophers. When they exhaust the food supply there, they will move out to any nearby reforested areas and eat the roots of seedlings. Deer find apples appetizing, so planting apple trees near newly planted stands or nurseries should be avoided.

Although wildlife is recognized as a valuable asset of our forests and grasslands, our demands for timber and other natural resources are growing constantly, requiring more intensive management to provide society's needs. Methods to protect reforestation seedlings include the use of fences, noises, barriers, special hunting seasons, habitat manipulation, individual seedling protectors, and chemical treatments.

As is true in integrated insect and vegetation pest management, chemical pesticides are resorted to only when other alternatives fail or are apt to prove ineffective. Rodents especially must often be controlled with rodenticides such as strychnine and zinc phosphide. These materials are usually placed by hand at bait stations, in burrows, or by impregnating conifer seed coats. The 5-year average (1982–86) for the use of rodenticides on National Forest System lands is 2,000 pounds on 70,000 acres.

Although not primarily related to forestry, a recent development in animal damage control is worth mentioning because of its ingenuity. Livestock owners, par-

Pesticide use for rodent control on National Forest System lands

	Acres	*Pounds*
1982	61,817	1,443
1983	57,697	3,009
1984	89,757	4,726
1985	72,199	2,869
1986	71,303	1,808

ticularly sheep producers, lose animals to predators, notably to coyotes in the West. Many control methods have been tried with varying degrees of success. Currently being tested with good results is a sheep collar containing a toxicant. When a coyote bites through the collar (up to 90 percent of coyote wounds on sheep are on the neck), it soon dies. Although expensive, this technique eliminates only animals that bite sheep in the neck. As a result of this kind of selectivity, future uses of predacides are likely to decline.

Pesticide use for predator control on National Forest System lands

	Acres	*Pounds*
1982	30,000	3
1983	30,000	4
1984	30,000	3
1985	30,000	8
1986	30,000	0.5

Strict safety precautions are required of all applicators handling these pesticides to ensure that no harm comes to people, the environment, or nontarget wildlife.

Pesticide Research

When research is mentioned, most people envision men and women in long white coats performing esoteric manipulations on long tables replete with bubbling retorts, Bunsen burners, and strange solutions in test tubes. Indeed this picture is accurate for some aspects of research conducted for forest pest control. Such laboratory work is performed on potential pesticide materials and includes microbiology, biochemistry, synthetic and analytical chemistry, toxicology, screening, bioassays, and development of formulations.

But research doesn't always start in the immaculate environment of the lab. Some starts in the dust and heat, mud and rain, and snow and cold of the outdoors. It starts with questions about satisfying society's needs: How can we satisfy the ever-growing demands for more paper, more recreation, more scenic retreats, more wildlife, cleaner air and water, more timber—more of everything forests and grasslands provide?

And how can these goals be accomplished with a constantly decreasing forest land base, without harming the environment, poisoning people, injuring beneficial creatures, or endangering economic stability?

An understanding of the questions—the research—often starts in the field. In a natural forest, for instance, bark beetles function to remove weak, damaged, or stressed trees, thereby benefiting the forest as a whole. The need for specific products, however, has led to the creation of unnatural forests. Plantations of thousands of trees all of one species are created, invitations to the particular bark beetles that feed on them or live in them. In this situation a beetle attack may start with a single tree, but it doesn't stop with that one tree. A whole banquet of trees surrounds it and a beetle epidemic ensues. Now the questions arise: How can we grow enough trees to provide the needed products without having them destroyed by pests? Can the trees be improved genetically to ward off insects? Can they be managed differently to discourage attack? Can a pesticide be developed that will protect the stands? Is there any solution at all? Field research, experimental plots, and observation will provide some answers. Others must be sought in the laboratory.

Most research on pesticides is concentrated on herbicides to control brush and vegetation that compete with desirable species and on insecticides to control damaging insect populations. Less effort is spent on fungicides to control tree diseases and chemicals designed for animal damage control.

Silvicultural techniques that result in vegetation control are preferred over chemical applications, and much herbicide research is aimed toward developing substances that can be used in conjunction with cultural operations. Such compounds are designed to release young conifers from brush and weed competition and to prepare sites for reforestation or interplanting with additional trees. This research includes studies of the behavior and toxicology of herbicides and their effects on the forest environment. Also determined are their persistence, movement, and breakdown in vegetation, soil, water, and on the forest floor. The chart below indicates the amounts of herbicides used in research.

Herbicide use in research on National Forest System lands

	Acres	*Pounds*
1982	172	483
1983	0	0
1984	21	39
1985	611	777
1986	237	107

Research on insecticides is confined chiefly to three classes of materials: 1) conventional insecticides; 2) novel chemicals such as behavior modifiers and growth regulators; and 3) biological materials represented by microbial insecticides (viruses and bacteria). Behavior modifiers, growth regulators, and microbials are alternatives to traditional chemical toxicants and they offer more selective pest control with a reduced potential for adverse effects on human health and the environment. Of the novel chemicals, insect pheromones have received the most attention by forest scientists. Pheromones are natural products of insects that modify behavior and cause insects to aggregate at a food source or help them to attract mates. The chart below indicates the amounts of insecticides and fungicides used in research.

Insecticide and fungicide use in research on National Forest System lands

	Acres	*Pounds*
1982	6	18
1983	4	12
1984	0	0
1985	1	21
1986	74	4

Forest Service researchers and others are working with the U.S. Environmental Protection Agency to register more of these materials and add them to the arsenal of pest management methods. For example, pheromones that can be used to manipulate Douglas-fir beetles and spruce beetles have been developed by Forest Service researchers, and the agency has requested registration. Researchers are also developing pheromones for operational use to manipulate such forest defoliators as the Douglas-fir tussock moth and the western pine shoot borer.

Cooperative Pest Management Programs

When most people think of the Forest Service, they think of uniformed forest "rangers," working on National Forests, stewards of Federal land belonging to all citizens. That idea is partially correct, but it doesn't cover the whole picture. In addition to managing National Forest System lands and doing research, the Forest Service also has a branch called "State and Private Forestry," or S&PF. One of the functions of the S&PF part of the Forest Service is to work with State foresters and private landowners, mostly in the areas of program and project coordination and technology transfer and in funding projects related to forest management, especially on pest-infested lands adjacent to or intermingled with Federal lands.

One such activity is pest control. The Forest Service, in conjunction with various States, cooperatively finances certain major pest control efforts.

Here are some examples of recent cooperative efforts:

Gypsy moth—Since its accidental release in the United States in 1869, the gypsy moth has spread throughout New England and areas to the south and west. It is now permanently established in all or parts of 14 States.

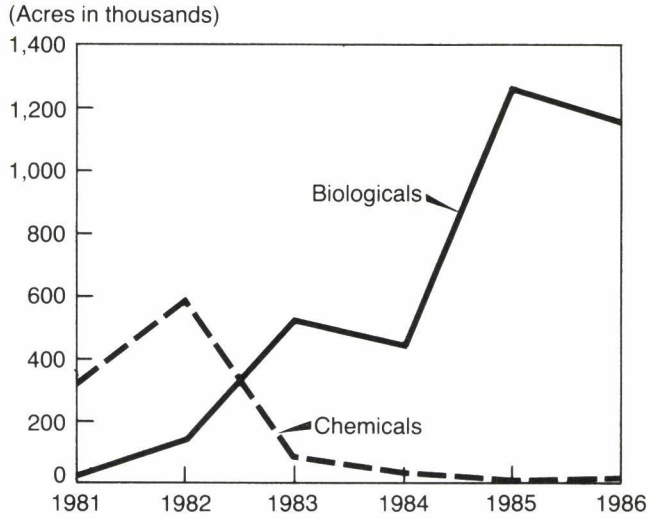
The gypsy moth has caused severe tree defoliation on more than 53 million acres since 1924. Fifty-six (56) percent of this, or 29 million acres, occurred during the period 1980-84. In 1985 significant defoliation in the United States occurred on 1.7 million acres, and in 1986 defoliation was noted on 2.4 million acres from Maine to Virginia. Localized, isolated infestations also occurred in the West in California, Oregon, and Washington.

Although most infestations to date have been on State and private lands, significant defoliation is beginning to be seen on National Forests in Virginia and Pennsylvania.

The USDA Forest Service in cooperation with the Animal and Plant Health Inspection Service and the States has supported the suppression and eradication of gypsy moth populations, and it continues to support the development of integrated pest management (IPM) strategies for this important defoliator.

For example, the following chart shows the agency's involvement in just one aspect of gypsy moth IPM—the use of pesticides. A unique trend shown by these data is the deemphasis on conventional chemical insecticides and the increased emphasis on the use of the biological insecticide *Bacillus thuringiensis* and the insect growth regulator diflubenzuron.

Chemical versus biological insecticide use for gypsy moth control, 1981-86.



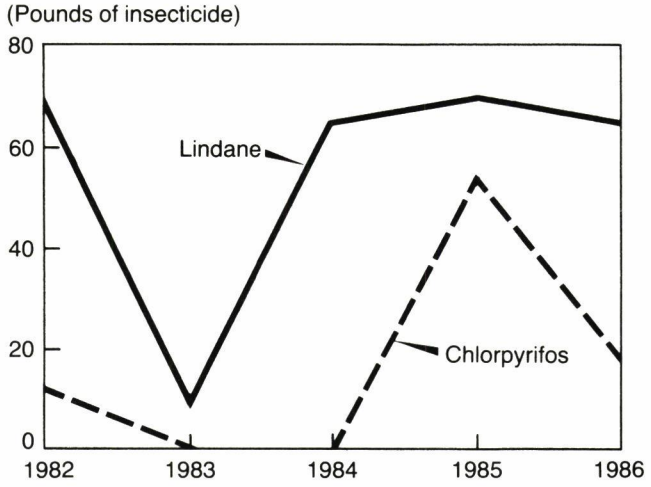
Southern pine beetle—The southern pine beetle (SPB) is a native bark beetle that periodically multiplies to epidemic proportions and kills thousands of pine trees from Texas to Virginia. In 1982 populations of SPB began an upward trend, killing significant numbers of pines in Arkansas, Louisiana, Mississippi, Alabama and Texas. Economic losses attributed to the beetle on State, private, and Federal lands are substantial. An average annual timber loss to this pest is estimated at $17.4 million.

Management of such extensive infestations is impractical without Federal financial and technical assistance. The Forest Service response has been to work with the States to cooperatively treat beetle-infested

spots to minimize outbreak impacts. Treatments have been applied directly on National Forests and through cooperative cost-share projects on State and private lands.

Pesticide use is minimal in managing the SPB since silvicultural techniques are the alternative of first choice, but chlorpyrifos and lindane have been used when silvicultural opportunities have been precluded. The chart below shows the patterns of use of these insecticides on the National Forests in the South over the past 5 years.

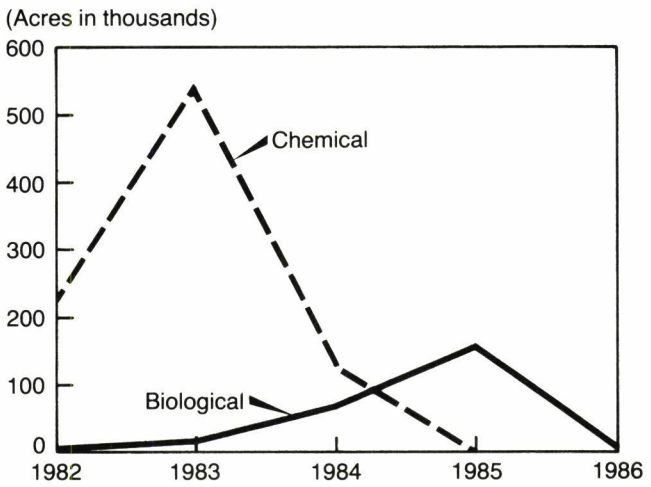
Insecticide use for southern pine beetle control on National Forest System lands, 1982-86.



Western spruce budworm—Like the southern pine beetle, the western spruce budworm (WSBW) is a native pest. It is a defoliator of coniferous forests and is usually held in check by its predators, parasites, healthy stand conditions, and the weather. Periodically, however, some of these factors get out of balance and a budworm outbreak occurs. In 1985 and 1986 the WSBW defoliated approximately 12 million acres of State, private, and Federal lands in the Rocky Mountains and the Pacific Northwest.

Cooperative treatment of the WSBW has been supported by the USDA Forest Service; however, limited funds have precluded the treatment of all acres for which financial assistance has been requested. The following chart does, however, show treatment of an average of 230,000 acres per year (1982-86). During that time, the insecticides acephate, *Bacillus thuringiensis,* carbaryl, and mexacarbate were used. As with gypsy moth treatments, there has been a trend toward decreased use of conventional chemical insecticides against this pest.

Chemical versus biological insecticide use for western spruce budworm control on National Forest System lands, 1982-86.



The Question of Risk

Few issues have held the public interest and created as much controversy during recent years as the question of pesticide use. Because of scientific uncertainty about the dangers of some conventional pesticides, greater efforts are being made today than ever before to ensure that pesticides, when needed, are used safely and with proper regard to their potential effects on people, wildlife, and the environment.

Often the scientific uncertainty stems from a lack of agreement among scientists themselves in interpreting data, a situation that almost always exists at some level in the scientific community. It is probably a good thing that concern has been raised in the minds of the public and users alike. There was a time when any chemical that would defeat a pest was used as quickly as it was discovered, with little or no regard to its impacts on people or the environment. Heightened awareness of the dangers of pesticides and sharper scrutiny of their application have ensured that those days are gone forever. Today the checks and balances that establish the safe use of a product begin years before it is available in the marketplace.

Ten or more years and a cost of $20 to $40 million is not an unusual outlay in the development of a pesticide. This might be called the first step in ensuring safety. This is the step that allows a product to meet the specifications of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended, and as administered by the U.S. Environmental Protection Agency (EPA). But registration by EPA is insufficient proof of safety in the eyes of many people and some courts. More is required and more is done.

When a pest problem arises on National Forest System lands, an analysis is conducted to determine how best to handle the problem. Both biological and economic assessments are included in the analysis. All methods of pest control are evaluated: manual, mechanical, cultural, biological, and chemical. Following the principles of integrated pest management, the management team may decide that one part of a site can be treated manually, another with biologicals, and a third with a chemical pesticide. When a chemical pesticide is required, and there is some uncertainty about that pesticide, a risk analysis is a further step toward ensuring safe use.

A word here about risk is in order. There is no such thing as a risk-free situation. Getting out of bed, taking a shower, and eating breakfast involve risks. We learn as we go through life that some risks are acceptable, even necessary, if we are to move at all. But because we perceive a risk as acceptable or unacceptable does not mean that our perceptions necessarily agree with fact. Most of us feel perfectly safe driving our own car to the supermarket for groceries, but we are tense in an airplane flyng from coast to coast. Any kind of analysis will show that we are much safer, much less likely to be injured, flying from coast to coast, but statistics make few of us feel more comfortable.

Ultimately we judge risk in terms of benefit or by comparison to other risks. Few of us have the time to drive from New York to Los Angeles. If we must make the trip, we go by air and accept the feeling of insecurity. The time-saving benefit outweighs the risk.

If you want to make a lot of money you can play the stock market—or you can go to Las Vegas and play the slots. As risky as the stock market may seem, it is certainly safer than plugging your money into a one-armed bandit. You make your decision on the basis of comparative risks.

Risk assessment as a discipline is relatively new. Specialists use mathematics to weigh risks and some specialists study risks within specific areas such as pesticide use. Many chemists, physicists, and bio-

logists have become specialists in pesticide risk analysis, and Forest Service studies are based on their work. Given adequate data, analysts can use mathematical formulas to ascertain comparative risk figures. For instance, calculations can show that a given pesticide used under certain specific conditions poses a one-in-ten, one-in-a-hundred, or one-in-a-million chance of injury to human beings. When an unacceptable risk is posed by a pesticide under the conditions in question, that method of dealing with the pest is rejected.

A risk analysis conducted by forest pest specialists does not set rigid guidelines, however. It is simply one factor among many prepared for decisionmakers to consider in evaluating a pest management situation. Among the other considerations is a determination that the pesticides being studied are registered with EPA for use against the pest in question. Each of these pesticides is then subjected to a detailed risk analysis that includes the characteristics of the site to be treated (including nearby homes, farms, bodies of water), the method of application, the amounts of pesticide to be used, people at risk (mixers, loaders, applicators, pilots, nearby dwellers, hunters, passers-by), animals at risk (domestic, wildlife, fish), and the characteristics of the pesticide (toxicity, environmental fate, carcinogenicity, mutagenicity, teratogenicity). These characteristics are gleaned from exhaustive literature searches. Where scientific uncertainty exists on any aspect of a pesticide, a risk assessment is performed, including evaluations of scenarios that could reasonably occur through accident or misapplication.

All kinds of possible exposure as well as the various kinds of events that could lead to cumulative exposure are analyzed. For example, drifting spray and brushing against foliage might expose a hunter's skin to pesticide. In addition, the hunter might eat a game animal and berries and drink stream water, all of which have received some amount of pesticide.

Safety factors are entered into these calculations. That is, an amount of pesticide is shown through experiments to be safe relative to the body weight of a laboratory test animal. A calculation will determine what that means relative to the body weight of a human. If, for instance, such a projection indicates that 100 milligrams of a substance would not harm a human, then 1 milligram is set as an acceptable dose; that is a safety factor of 100.

In addition to these analyses, other calculations are designed to determine effects on populations that may be especially sensitive: children, people with respiratory problems, and pregnant women are among the groups so considered.

Another aspect of pesticide exposure that is studied is synergism, that is, the possibility that two substances will have a greater effect in combination than would be expected from the additive effects. Such an effect is seen when a person who smokes is exposed to asbestos. The expectation of lung cancer from smoking is known. So is the expectation from breathing asbestos dust. Actual experience shows, however, that a person exposed to both is 10 times more likely to develop cancer than would be expected from calculating the risk of one added to the risk from the other.

When all these analyses have been completed, any pesticide that poses an unacceptable risk to people, wildlife, or the environment is eliminated from consideration.

Summary

Trees are one of the very few renewable resources given us. But they must be cared for diligently if they are to continue to provide the many products our society relies on. Increasing population pressure and growing urbanization are making constant inroads on available land. Thousands of acres have become unproductive through improper land management. These and other factors make it necessary for resource managers to use every available tool to ensure maximum productivity from our woodlands, and that productivity includes clean air and water, wildlife habitat, recreational facilities, and esthetics, as well as the more tangible products such as paper, timber, and turpentine.

We have strong competition for the use of our forests and rangelands. Insects, rodents, fungi, diseases, toxic and noxious weeds—all strive to exist and grow to the detriment of the needs of human society. To combat them, the USDA Forest Service has armed itself with an arsenal of great variety: silviculture; mechanical, manual, and thermal techniques; biologicals; and chemical pesticides.

Inaccessibility, epidemics, vast land areas, rapid pest migrations, and invasions of exotic life forms create problems that often can be solved only with chemical pesticides. In such cases, they are the fastest acting, safest, and most cost-efficient means for controlling pests. The judicious use of pesticides can ensure that our forests and rangelands meet the needs of society today and the demands of future generations.

As part of its resource management program, the Forest Service keeps accurate records of pesticide use. The following table summarizes the major categories of pest control for 1982–86 on National Forest System land. (See table on reverse side.)

Average pesticide use on National Forest System lands, 1982–86

Activity	Pesticide use	
Vegetation Management	*Acres*	*Pounds*
Noxious weed control	14,472.0	23,182.2
Range Management	15,671.6	22,349.8
Release	76,490.8	149,802.0
Site preparation	56,074.4	113,241.8
Thinning	2,435.6	3,973.6
Rights-of-way	9,271.8	28,154.2
General weed control	1,826.6	4,085.6
Firebreak management	747.8	3,273.4
Wildlife habitat management	6,978.6	12,483.8
Nursery weed control	1,124.2	3,206.6
Aquatic weed control	185.4	850.4
Research	208.2	279.4
Total herbicide use	185,487.8	364,882.8
Insect and Disease Control		
Insect control	472,972.0	361,984.0
Disease control	4,312.4	81,734.0
Total	477,284.4	443,718.0
Animal Damage Control		
Predator control	30,000.0	3.7
Rodent control	70,554.6	2,771.0
Animal repellancy	21,771.8	5,626.8
Trash fish control	2,006.2	455.4
Total[1]	124,332.6	8,856.9
Grand Total 5-Year Average	787,104.8	817,457.7

[1]Several minor-use activities not included. Therefore, the total represents the average of only the selected management activities.

Credits

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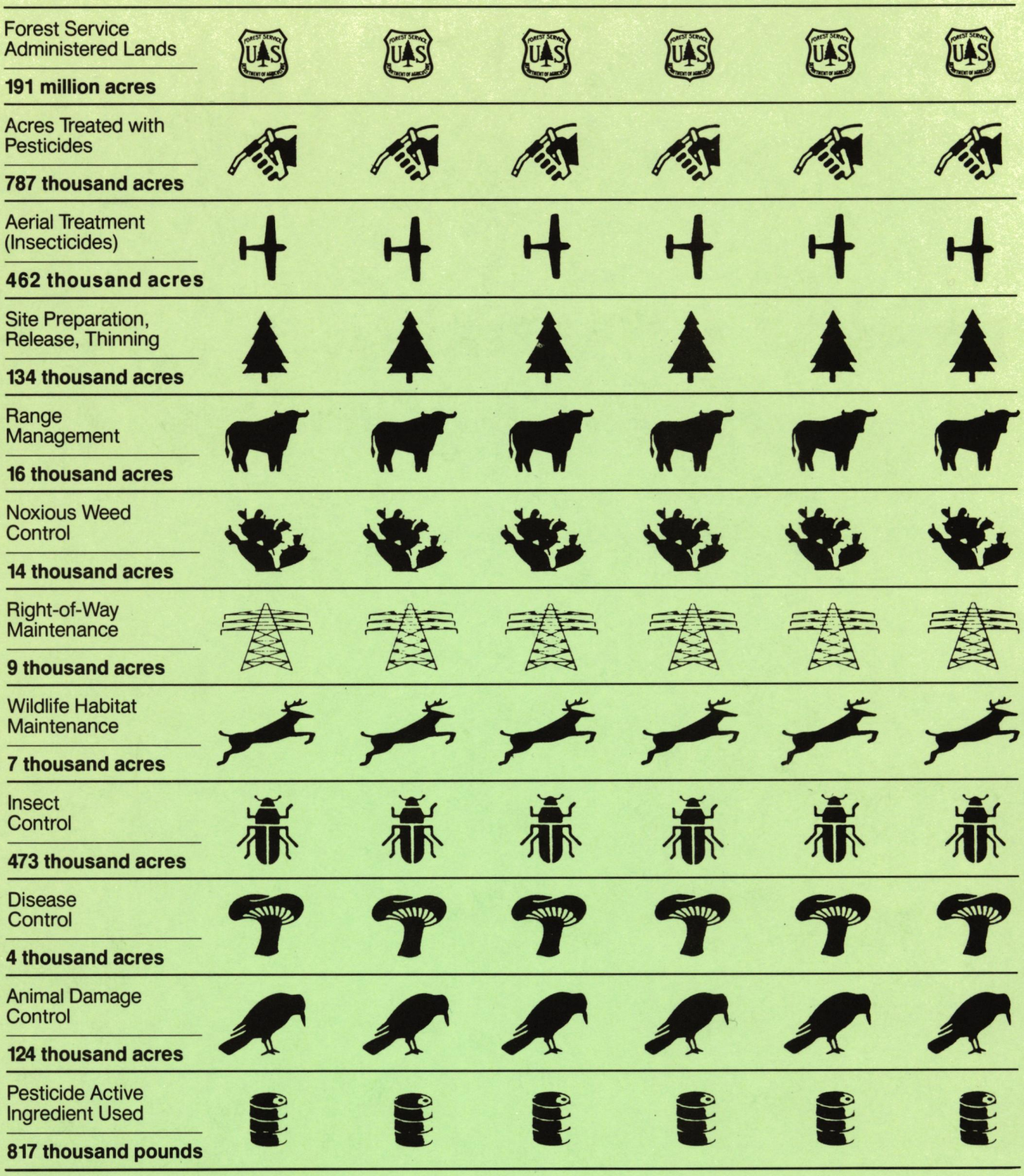
Pesticide Use Statistics*



*Based on 5-year averages, 1982-86

Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

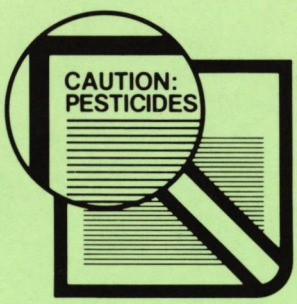
Store pesticides in original containers under lock and key — out of the reach of children and animals — and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides: Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.